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ROLE OF PERIOSTEUM AND BONE MARROW IN LENGTHENING : A QUANTITATIVE STUDY IN RABBITS USING DEXA

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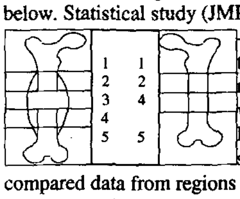
INTRODUCTION: This study values quantitatively the bone formation due to periosteum and/or bone marrow-endosteum in distraction osteogenesis.

MATERIALS AND METHODS: Surgical procedure. One femur of 18 NZW 2.4-3.0 kg rabbits was fitted with a custom-made external fixator (contralateral one=control). Periosteum (P) and bone marrow (BM) were treated, according to their preservation $^{(+)}$ or destruction $(^-)$: P^+: P elevated ; P^-: P stripped from the bone; BM^+: corticotomy ; BM^-: marrow cavity filled with PMMA. *4 surgical groups were individualized:* 1) P^+BM^+ (5 animals); 2) P^+BM^- (5); 3) P^-BM^+ (5); 4) P^-BM^- (3). From POD 5, femora were lengthened 0.25 mmx2/Day until POD 25. At sacrifice on POD 30, femora were harvested with a 0.5 to 1.0 mm muscle layer. Dual energy x-ray absorptiometry study (QDR1000, Hologic). The area, bone mineral content (BMC) and density (BMD) were calculated. Femora were divided into 5 regions of interest (operated), or 4 (control), as shown below. Statistical study (JMP V2.0, SAS). Values (% obtained=[op. femur - non-op. femur]/op. femur) were transformed to range between 0 and 1, then to ensure a normal distribution (arcsin). The P effect (P^+ vs. P^-, *without considering the role of BM*), BM (BM^+ vs. BM^-), and their interaction were studied. ANOVA and MANOVA tests compared data from regions 1-5 and 2-4. Differences between groups were analysed (Tukey-Kramer test).



RESULTS: *X-ray evaluation:* BM forms bone around the distraction area. P spreads new bone almost entirely along the diaphysis., P^-BM^- : *no* bone deposition is seen around the distraction gap, nor in the muscle. *Percent increase in area, BMC & BMD with respect to the contralateral bone :* Table I. *Statistical analysis on the transformed data :* Table II. The comparison of surgical groups showed a significant difference for area (p=0.0008), BMC (p=0.0004) & BMD (p=0.004) in the whole specimens. Tukey-Kramer test : significant differences between surgical groups 1 and 4, 2 and 3, 2 and 4. For the 3 central regions, similar results, but greater significant difference (p<0.0001, area and BMC, not BMD).

DISCUSSION: Quantitatively, the P contributes more than the BM (group 1 vs 3) to healing in distraction. The *interaction* between P and BM is significant. The *spatial distribution* of the bone formed is different for P and BM: BM deposits new bone around itself, at the fracture or distraction site, and P forms bone along the elevated P and covers a larger area. When BM is destroyed, *periosteal bone formation fills the distraction gap.* Groups with *destruction of BM and P* failed to produce new bone around the distraction gap.

CONCLUSION: A *synergistic effect* (spatial and qualitative) may result from the combination of periosteum and bone marrow-endosteum in bone healing.

Group	Area	BMC	BMD
W P^+BM^+	20+/-5	36+/-16	13+/-9
P^-BM^+	27+/-7	45+/-13	13+/-4
P^+BM^-	12+/-3	11+/-9	9+/-6
P^-BM^-	7+/-6	3+/-6	-4+/-3
C P^+BM^+	63+/-18	81+/-42	63+/-29
P^-BM^+	82+/-18	127+/-14	83+/-11
P^+BM^-	29+/-17	25+/-16	47+/-27
P^-BM^-	1+/-3	-8+/-10	-10+/-7

Table I. Measurements on the whole specimens (W) and in the 3 central regions (C) in the 4 groups: % increase in area, BMC and BMD, for the op. femur / non-op. femur (mean ∀ 1 SD).

	Area *p*	BMC *p*	BMD *p*
W P	+ *p=0.0002*	+ *p=0.0002*	+ *p=0.0062*
B	-	-	-
P/B	+ *p=0.0315*	-	-
C P	+ *p=0.0002*	+ *p=0.0002*	+*p=0.0062*
B	-	-	-
P/B	+ *p=0.0315*	-	-

Table II. Effects (+ or -, with probability *p*) of Periosteum (P), bone marrow (B) and interaction P/BM (P/B) on the area, BMC & BMD of the whole specimens (W) and of the 3 central regions of interest, around the distraction gap (C).

IN VIVO DETERMINATION OF INTERNAL/EXTERNAL ROTATION OF THE FEMUR RELATIVE TO THE TIBIA

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INTRODUCTION: The exact pattern of axial tibiofemoral rotation after TKA is unclear. The objective of this study was to assess in vivo axial tibiofemoral rotation after posterior cruciate retaining (PCR) and posterior cruciate substituting (PS) total knee arthroplasty (TKA).

METHODS: Thirty-two subjects (19 PS, 13 PCR) were studied under fluoroscopic surveillance performing weightbearing deep knee bends to maximum flexion. Three-dimensional solid CAD models of the femoral and tibial components were fit onto the 2-D silhouette images using a model fitting technique [1]. Femorotibial contact paths for the medial and lateral condyles were determined for the four flexion angles. A line was then created from the medial condyle contact point to the lateral condyle contact point. The angle between this line and the midline of the tibia in the coronal plane was measured and denoted as the screwhome angle. A positive angle was denoted as normal screwhome rotation (tibia internally rotates with flexion) and a negative angle was denoted as reverse screwhome rotation.

RESULTS: Previous studies have shown that the normal knee exhibits between 10 and 16 degrees of screwhome rotation during flexion [1]. The average amount of screwhome rotation for subjects in this study was 9.74 and 0.55 degrees for the PS and PCR-implanted knees, respectively. All 19 subjects having a PS-implanted knee and 9 of 13 subjects having a PCR-implanted knee exhibited a normal screwhome pattern from 0 to 90 degrees of knee flexion. Four of the subjects having a PCR-implanted *knee demonstrated a reverse screwhome pattern. Rotational patterns in* both groups were erratic, with 10 of 16 subjects with a PS TKA (62.5 percent) and 10 of 13 with a PCR TKA (76.9 percent) demonstrating a reverse screwhome pattern at one of the three evaluated flexion ranges, most commonly at 60-90 degrees.

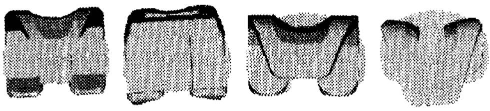

Figure 1. PS TKA at 0, 30, 60 and 90 degrees.

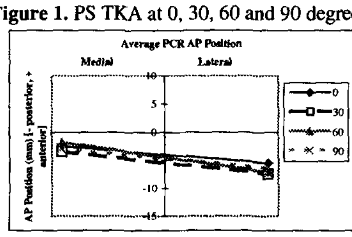

Figure 2. Average screwhome values for PCR TKA

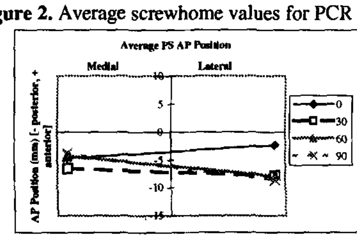

Figure 3. Average screwhome values for PS TKA

CONCLUSION: This analysis demonstrates reverse screwhome rotation can occur, most commonly after PCR TKA. This may be related, in part, to abnormal anterior femoral translation during flexion that has been observed in previous in vivo kinematic studies. Reverse screwhome rotation is potentially detrimental, enhancing the risk of patellofemoral *instability, and premature polyethylene wear.*

REFERENCES: [1] Dennis DA, et al.: *Clin Orthop*, 1996.

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